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FINAL REPORT

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THE DEVELOPMENT OF A QUALITATIVE SYSTEM TO EVALUATE POPULATIONS OF CHANNEL CATFISH AND FLATHEAD CATFISH IN THE MISSOURI AND MISSISSIPPI RIVERS

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ABSTRACT

Managers of big river catfish populations want to know current population status and how it compares to previous samples or other populations in similar environments, and they need a standardized methodology to make the assessment. This study was initiated to determine how to collect large numbers of channel catfish and flathead catfish in a short period of time, and to provide baseline information useful to assess channel catfish and flathead catfish populations in the Missouri and Mississippi rivers.

Channel catfish and flathead catfish were sampled in the Missouri and Mississippi rivers from 1980 to 1992 with standardized techniques, and populations were assessed with capture rates, growth rates, size and age structure, mortality rates, and population modeling. Channel catfish were sampled at one site on the Missouri River with baited hoop nets. Flathead catfish were sampled at four sites on the Missouri River and two sites on the Mississippi River by pulsed DC electrofishing. Channel catfish 10.0 inches and longer, and flathead catfish 6.0 inches and longer were considered fully recruited to the sampling gear.

More than 9,000 channel catfish were collected. Average total length was 10.4 inches. Total capture rates averaged 5.0 channel catfish per hoop net day and were higher than from other studies in the Missouri River and other Midwest rivers. The channel catfish population was comprised primarily of fish less than 15.0 inches and 6 years old. Annual recruitment, although not directly measured, was consistent and adequate based upon the number of 8.0- to 10.0-inch fish in annual samples. Growth was acceptable and similar to that reported for other studies. Channel catfish 15.0 inches and longer comprised approximately 21% (range 9-33 %) of the stock-size fish (fish larger than 11.0 inches), but they comprised less than 15 % in samples during 5 of the last 6 years. Fish between 16.0 and 23.9 inches comprised an average of 14 % of the stock, but less than 8% during 5 of the last 6 years. Channel catfish greater than 24.0 inches represented less than 1% of the stock. Total annual mortality rates averaged 58 % . Population modeling suggested a reduction in mortality to 40 % would increase

the numbers of channel catfish larger than 15.0 inches to approximately 25 % of the 11.0-inch and larger population.

More than 34,000 flathead catfish were collected. Average total length was 8.9 inches. Total capture rates averaged 1.5 flathead catfish per minute and were higher than those reported for other studies from the Missouri and Mississippi rivers. The flathead catfish population consisted primarily of fish less than 15.0 inches and 5 years old. Annual recruitment, although not directly measured, was consistent and adequate based upon the numbers of 6.0-inch and longer fish in annual samples. Growth was acceptable and similar to that reported for other studies. During this study approximately 25 % of the stock-size fish (11.0-inch and longer fish) were 15.0 inches or larger. Fish between 16.0 and 23.9 inches averaged 15% of stock; fish between 24.0 and 27.9 inches and fish between 28.0 and 35.9 inches each averaged 1% of stock; and fish larger than 36.0 inches comprised less than 1% of the stock. Total annual mortality rates averaged 53%. Population modeling suggested a reduction in mortality to 40 % would improve the size structure and increase the numbers of flathead catfish larger than 15.0 inches to 35 % of the 11.0-inch and larger population.

INTRODUCTION

The Missouri and Mississippi rivers provide more than 1,000 miles and 264,000 surface acres of aquatic habitat in Missouri and support many river-oriented activities, including sport and commercial fishing. Channelization of the Missouri River and a series of locks and dams and channelization of the Mississippi River to improve navigation, have adversely affected physical habitat, flow characteristics and fish populations (Hesse et al. 1989; Funk and Robinson 1974; and Fremling et al. 1989). Between 1879 and 1972, the surface area of the lower Missouri River below Rulo,
Nebraska was reduced by 50%; the length of the river was shortened by 49 miles; and most islands and associated secondary side channels were eliminated (Funk and Robinson 1974).

Although substantially altered, the Missouri River in Missouri still provides considerable recreation (Fleener 1989). Fishing, the most favored activity, accounted for 31-40% of the estimated 2.5 million river related visits during the 4-year study with channel catfish and flathead catfish the most sought after species. By 1990, commercial fish harvest from the Missouri and Mississippi rivers had increased to near 2,000,000 pounds with catfish species (the most sought after commercial fishes) accounting for almost one-third of the harvest, despite declining numbers of commercial anglers (Figure 1).

An increase in commercial catfish harvest, a continuing decline in riverine habitat diversity because of channelization and agricultural leveeing within the floodplain, and a perceived decline in the size structure of catfish, led to our assessment of big river catfish populations in Missouri beginning in 1980. Robinson (1994) reported that channel catfish and flathead catfish populations consisted mostly of individuals less than 15.0 inches long, a further indication of the need for this assessment. Blue catfish, although abundant, were not collected in sufficient numbers to assess population status for the species.

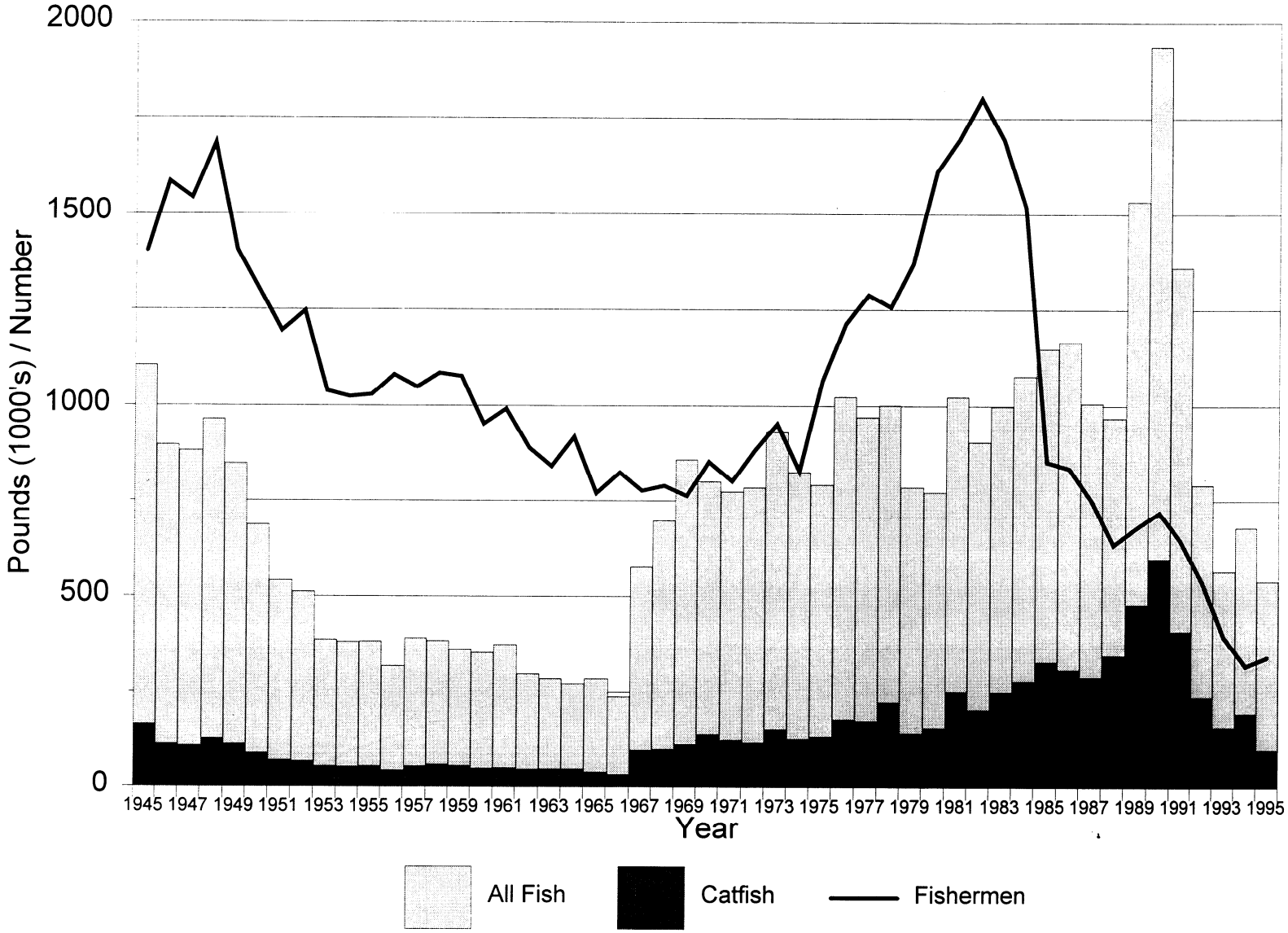

Figure 1. The number of commercial fishermen and their reported harvest of all fish and catfish from the Missouri, Mississippi, and St. Francis rivers, 1945 - 1995.

Managing fish populations in big rivers is challenging because of river size, swift currents, relatively deep water, and temporal flow variation. Rather than rely on population estimates, managers must use population indices to identify problems and assess success or failure of management efforts. Managers ultimately want to know the current population status and how it compares to previous samples or other populations in similar environments, and they need standardized methodology to help make the assessment (Robinson 1994). My study objectives were to: 1) determine the most effective sampling methods and techniques to obtain a representative sample for assessing populations of channel catfish and flathead catfish; 2) develop a qualitative method to assess the status of populations of flathead catfish and channel catfish in the Missouri River using selected criteria (such as growth rates, age structure, relative density, etc.) and to establish ranges of values for each; and 3) assess the status of flathead catfish and channel catfish populations in those portions of the Missouri and Mississippi rivers which border or flow through Missouri.

Objective 1 has been completed and reported (Robinson 1994). I was unable to develop a qualitative method to assess catfish populations using population parameters similar to those described by Colvin and Vasey (1986) and Kruse (1988) (Objective 2) because there were no standards for comparison. The channel catfish and flathead catfish populations in the Missouri and Mississippi rivers were affected by habitat and the environmental conditions of these altered rivers, and it was not possible to measure the extent these populations had been affected or how much improvement is possible. Consequently, I focused on collecting baseline information to assess the channel catfish and flathead catfish populations in the Missouri and Mississippi rivers in Missouri using catch rates, size and age structure, growth, and mortality rate information.

Standardized sampling techniques described by Robinson (1994), and this assessment of the current population status, will provide a standardized approach to sampling and assessing channel

catfish and flathead catfish populations in large river systems like the Missouri and Mississippi rivers, and will provide baseline population information to determine future changes.

STUDY AREAS

Representative study sites on the Missouri and Mississippi rivers, used to assess channel catfish and flathead catfish populations, are presented in Figure 2. Channel catfish were only collected from the Missouri River near Easley; flathead catfish were collected from four sites on the Missouri River (near St. Joseph, Lexington, Glasgow, and Easley) and two sites on the Mississippi River (near Crystal City and Cape Girardeau). Sites were sampled annually from 1980 to 1992. Robinson (1994) provides a more detailed description of individual study sections.

METHODS AND GENERAL APPROACH

Channel catfish and flathead catfish populations in the Missouri and Mississippi rivers were assessed by examining data from three sources: long-term standardized catch data, population data from other studies, and population modeling to determine how characteristics changed with different mortality levels. The parameters used to evaluate populations were capture rates (CPUE), growth rates, size and age structure (RSD) (Anderson and Weithman 1978; Gabelhouse 1984), and mortality rates. I compared length frequency information to determine at what size catfish became vulnerable to sampling, used catch rates, RSD, and length frequency distributions to compare Missouri and Mississippi river catfish populations to other riverine catfish populations where similar capture methods were used, and I used age frequency distributions to determine total annual mortality rates and to develop population models.

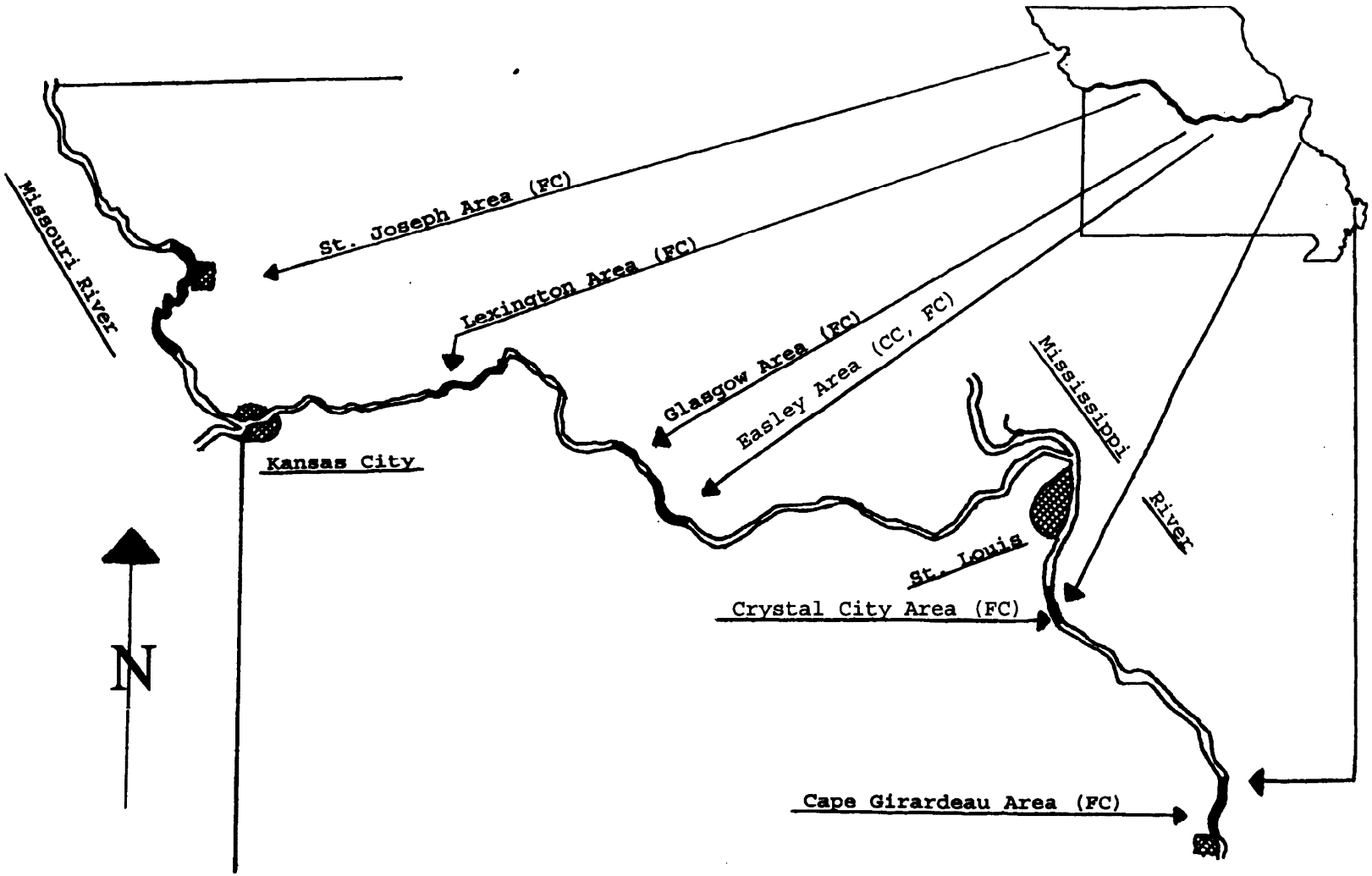

Figure 2. Areas where flathead catfish (FC) and channel catfish (CC) were sampled, 1980-1992.

POPULATION SAMPLING

Channel catfish were sampled using 1-inch mesh, cheese-baited hoop nets, set during August to November in areas with a hard, clean, sand bottom and strong current, and in water depths of 4-6 feet. Hoop nets capture a broad range of sizes; however, only those channel catfish 10.0 inches and longer were considered fully recruited to the sampling gear. Flathead catfish were sampled by electrofishing in the Missouri and Mississippi rivers using pulsed DC, from rock habitats with a strong current during August-September when water temperature was above 70° F. Electrofishing captures all sizes of flathead catfish; however, only those individuals 6.0 inches and longer were considered to be fully recruited to the sampling gear (Robinson 1994). Robinson (1994) determined that a representative sample in the Missouri and Mississippi consisted of at least 300 flathead catfish and 400 channel catfish collected per study site per year.

Population structure was determined graphically using catch rate information from 1-inch length groups for channel catfish and flathead catfish. Initially, I compared sampling sites and sampling years to determine whether there were any measurable differences. No differences could be detected, so I combined data to assess channel catfish and flathead catfish populations for this report. Population indices were determined from length and age frequencies. Flathead catfish sampling data from individual sampling sites and rivers are presented in Appendices A-L.

Mortality rate calculations followed conventions presented by Ricker (1975). A linear regression of the natural log of frequency for each age was used to determine total instantaneous mortality (Z). Only fully recruited age-classes were used: Age 3 (10.0 inches total length) and older for channel catfish, and Age 2 (6.0 inches total length) and older for flathead catfish. Total annual mortality (A) was estimated by the equation $A = 1 - e^{-Z}$ from a catch curve developed for both channel catfish and flathead catfish populations.

COMPARISONS WITH OTHER POPULATIONS

I compared channel catfish and flathead catfish population information collected for this study to information from selected catfish studies, which had been conducted in similar environments, and by standardized methods. These included studies on the Missouri and Mississippi rivers in other states and on lightly fished rivers in the Midwest and northern states (Hesse et al. 1978, Nebraska Game and Parks Commission 1982, Holz 1969, Smith and Hubert 1988, Gerhardt and Hubert 1991, Gerhardt 1989, Kubeny 1992, Ragland and Robinson 1972, and Topp et al. 1994). In addition to catch rate information, I calculated population indices such as Relative Stock Density (RSD) (Gablehouse 1984) using the author's information.

POPULATION MODELS

I modeled channel catfish and flathead catfish populations for this study at four annual mortality rates, 30%, 40%, 50%, and 60 % to determine changes in population characteristics and indices which managers might encounter under different environmental conditions, fishing pressures or regulations. Modeling included length and age relationships and changes in population indices (RSD).

POPULATION PARAMETERS

Capture Rates

Standardized capture rates for channel catfish (channel catfish per hoop net day: cc/hnd) and flathead catfish (flathead catfish per minute: fhc/m) were used to develop population length frequency distributions as an index of catfish population density and relative abundance, and to develop graphical representations of catfish populations in the Missouri and Mississippi rivers. Catfish catch rates, when collected in a standardized manner, and over a number of years, provide a measure of sampling success and an index of population abundance.

Indices developed from standardized catch information help managers understand population dynamics and changes in population dynamics over time. Although more variable than population estimates, standardized catch information and indices developed from the information can be used to compare populations between sampling sites, rivers, and similar studies.

In most cases, 1-inch hoop nets and pulsed DC electrofishing sampling methods do not collect small and young catfish in proportion to their abundance in the population; consequently, biologists using catch rate information must determine the size and age when channel catfish and flathead catfish become fully recruited to the sampling gear. Using length frequency information, I determined that channel catfish in the Missouri River were fully recruited to the sampling gear (1-inch mesh hoop nets) at a total length of 10.0 inches and flathead catfish (electrofishing) at 6.0 inches.

I compared channel catfish capture rates to river conditions at the time sampling occurred. Gage height (Sample GH) and gage index (Sample GI) information (Hesse 1987) and catch rates were compared using correlation coefficients (Ott 1993). Sample GH is the sum of daily gage height information from the Missouri River recording gage nearest the study site, divided by the number of days in the sample period. Sample GI is the sum of the daily difference between high and low flows divided by the number of days in the sample period. Biologists can compare catch rate information to river conditions (GH and GI) and assess the adequacy of their sample and how it might have been affected by river conditions.

A population structure developed from standardized catch information, enables biologists to calculate other population indices including RSD, mortality rates, and develop population models.

Growth Rates

Growth rate information can be used to compare growth differences between size groups; to determine differences in growth between sampling areas, populations, years, and studies; and to assess the general health of the studied population. Information on fish growth and relative numbers of

individuals in a population helps assess the effects of harvest and changes in the environment. For example, a catfish population with rapid growth might be managed differently than a slow-growth population or a population with numerous old and large individuals. To determine growth rates and age of channel catfish and flathead catfish, I removed the right pectoral spine from 10 fish in each 1-inch length group (starting at 6.0 inches) from collections made from 1988 to 1992.

Spines were cleaned using the procedure described by Dames (1988), then sectioned with a low-speed Buehler Isomet saw with a high concentration diamond wafering blade, then aged with a micro projector. The sectioned spines were aged by identifying annual growth rings, growth rates calculated, and the results applied to length frequency information to develop age frequency distributions (Ricker 1975). I assumed that catfish captured in the fall were at, or near, the end of the growth year. This information was used to calculate mortality rates.

Size Structure

A fish population structure developed from standardized catch information, inch groups or age groups, provides a graphical representation of the population at one point in time. A length frequency size structure can be used to measure mortality rates, develop population indices such as RSD, and compare differences in indices between study areas, years, other studies, and rivers. In my study, channel catfish were not recruited fully to the sampling gear until they reached 10.0 inches and age 3; flathead catfish at 6.0 inches and age 2. Because of this, I made no attempt to measure recruitment directly. There were always large numbers of 10.0-inch channel catfish (Table 1 and Figure 3) and 6.0-inch flathead catfish in annual samples (Appendices A-L), and I assumed recruitment was adequate and relatively consistent.

Relative Stock Density (RSD) indices can be used to define population objectives (Anderson and Weithman 1978, and Gabelhouse 1984). RSD is the ratio of the number of fish longer than a specific size, such as 15.0 inches and larger, to the number of stock length (11.0 inches) and larger fish

in the population, expressed as a percentage. To define and assess the channel catfish and flathead catfish populations in the Missouri and Mississippi rivers, I used RSD_{15}, the size that commercial anglers were allowed to harvest and a size important to sport anglers, and Gabelhouse's (1984) incremental approach to RSD. The population was defined by the following length ranges from Gablehouse (1984) : 11.0 to 15.9 inches, stock size fish (RSD_{s-q}); 16.0 to 23.9 inches, quality size fish (RSD_{q-p}); 24.0 to 27.9 inches, preferred size fish (RSD_{p-m}); 28.0 to 35.9 inches, memorable size fish (RSD.m-t,); and 36.0 inches and larger trophy size (RSDt).

Age Structure and Mortality rates

The age structure of a fish population developed from catch rates and aging of fish, provides a graphical representation of the numbers of individuals in each age group, a measure of the change over time in the population, and a measure of total annual mortality. The population age structure also was used in modeling of catfish populations using different mortality rates. Changes in management or changes in the environment should be reflected by changes in the population age composition and in changes in total annual mortality rates of individual age groups.

I aged channel catfish and flathead catfish, as described previously, and developed an age structure for each population; calculated mortality rates for age 3 and older channel catfish and age 2 and older flathead catfish; and determined the relative importance of each age group to the total population using techniques presented by Ricker (1975).

RESULTS AND DISCUSSION

The results of channel catfish and flathead catfish population sampling in the Missouri and Mississippi rivers are presented and discussed separately, followed by a summary of major findings. Additional sampling information for flathead catfish from individual sites and rivers, and figures describing the sampling data are presented in Appendices A-L for reference.

Channel Catfish

I collected 9,185 channel catfish during 1,829 hoop net days of sampling from the Missouri River from 1980 to 1992 (Table 1; and Figure 3). Channel catfish ranged from 2.3 inches to 26.3 inches and averaged 10.4 inches. Forty-five percent were less than 10 inches total length; 55 % were 10 inches and longer.

Channel Catfish Population Parameters

Capture Rates

Catch rates for all channel catfish averaged 5.0 cc/hnd, and ranged from 1.2 cc/hnd in 1986 to 8.5 cc/hnd in 1988 (Table 1). Catch rates for channel catfish less than 10.0 inches total length, averaged 2.2 cc/hnd and ranged from 0.5 cc/hnd (1986) to 6.5 cc/hnd (1988), and for fish 10.0 inches and larger averaged 2.8 cc/hnd and ranged from 0.7 cc/hnd (1986) to 5.2 cc/hnd (1989).

Comparisons of channel catfish catch rates from this study with similar studies on the Missouri River in Nebraska (Hesse at al. 1978, Nebraska Game and Parks Commission 1982) and Missouri (Ragland and Robinson, 1972), and with studies on the James River in South Dakota (Kubeny 1992), Powder River in Wyoming (Gerhardt 1989, Gerhardt and Hubert 1991, Smith and Hubert 1988), Red River in Minnesota (Topp et al. 1994), and other large rivers in the Midwest demonstrated our catch rates were similar or higher (Table 2). In all cases, catch rates from individual sample sites and years were variable, which emphasized the need for long-term studies and the use of large data set to reduce sampling variability.

Average channel catfish catch rates from our study (5.0 cc/hnd) and catch rates for 10-inch and larger catfish (2.8 cc/hnd) were similar or higher than those reported by Hesse et al. (1982), much higher than those reported previously for the Missouri River (Ragland and Robinson 1972), the Lower James River in South Dakota (Kubeny 1992), Powder River in Wyoming (Smith and Hubert 1988,

Table 1. Population parameters, gage height, gage index, and annual mortality rates for channel catfish from the Missouri River at Easley, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught	522	271	264	860	1335	1417	216	592	938	768	619	636	747	
Total CPUE	6.4	6.3	2.4	4.5	8.1	4.4	1.2	5.4	8.5	8.4	4.1	4.7	5.7	5.0
CPUE < 10 in	2.9	1.9	0.9	1.4	4.1	2.2	0.5	1.2	6.5	3.2	1.5	2.1	2.2	2.2
CPUE > = 10 in	3.5	4.4	1.5	3.0	4.0	2.2	0.7	4.1	2.0	5.2	2.6	2.6	3.5	2.8
% < 10 in	46	30	38	32	51	49	39	23	77	38	47	44	39	45
% > 10 in	54	70	62	68	49	51	61	77	23	62	53	56	61	55
RSD_{15}	27	31	19	20	25	33	26	13	33	9	12	14	15	21
$RSD_{11-15.9}$ (stock)	79	75	87	85	83	75	78	92	80	95	94	94	93	86
$RSD_{15-20-39}$ (quality)	21	25	13	15	17	24	22	8	19	5	5	6	6	14
$RSD_{24-27.9}$ (preferred)	0	<1	0	0	<1	<1	0	0	1	0	1	0	1	<1
RSD28-35.9 (memorable)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual Mortality														
Sample G I*	3.4	7.0	9.1	1.7	2.7	9.0	9.4	1.8	2.9	2.2	1.4	1.2	7.0	
Sample G H*	8.8	10.9	16.4	10.7	12.1	13.1	18.6	9.6	8.0	8.1	7.4	7.6	12.	
	45	67	58	61	55	58								

* Data from Boonville gage located at approximate Missouri River mile 197

Gerhardt 1989, and Gerhardt and Hubert 1991), and the Mississippi River in Missouri (Farabee pers. comm.).

Catch rates for catfish less than 10.0 inches, even though this segment of the population was not fully recruited to the sampling gear, were also higher than those reported in other studies, especially from lightly fished rivers further north (Gerhardt 1989, Gerhardt and Hubert 1991, Smith and Hubert 1988, and Kubeny 1992). Generally, I found that for fish 10.0 inches and larger, catch rates were higher in the Missouri River (our study and other studies) and other Midwest rivers than for northern rivers in Wyoming and South Dakota.

Based on comparisons of catch rates from other streams and studies, the Missouri River channel catfish catch rates at Easley Missouri suggested an average or above average population; however, the population contained relatively few, old, large channel catfish (Table 2). Lightly fished catfish populations in the Powder River, Wyoming; and the lower James River, South Dakota, had more large, old individuals (Table 2).

Comparisons of channel catfish catch rates with Gage Height (Sample GH) and a Gage Index (Sample GI) suggest that high water flow reduced catch rates (Table 1). Robinson (1994) determined that to have a representative sample of channel catfish required 400 fish; a smaller sample size may not accurately describe the population. I collected less than 400 channel catfish in 1981, 1982 and 1986. River stage (GH) and flow (GI) in 1982 and 1986 were high. Statistical comparisons of total channel catfish catch rates with GH ($r = -0.67$; $p < 0.01$) and GI ($r = -0.54$; $p = 0.06$) indices were both significant, suggesting that as flow increased catch rates decreased. When GH readings exceeded 14 feet, dikes were covered, hoop net sample sites changed, the river widened and deepened, and the current increased making sampling difficult and less efficient. While river conditions, as suggested by gage information, does not entirely explain low or high catch rates, it can help managers assess sample efficiencies and understand catch rate differences between sample areas and years.

Table 2. Catch rates, selected population parameters and annual mortality rates for channel catfish and flathead catfish from selected Midwest rivers.

CHANNEL CATFISH	Total Number	Total CPUE	CPUE < 10 in	CPUE > = 10 in	Percent < 10 in	Percent > = 10 in	RSD$_{S}$	RSD$_{11-15.9}$ (stock)	RSD$_{16-23.9}$ (quality)	RSD24-$_{29}$ (preferred)	RSD28-35.9., (memorable)	Annual Mortality
This study	9,185	5.0	2.2	2.8	45	55	21	86	14	<1	0	58
Ragland and Robinson 1972 MO	451	0.7	0.1	0.6	14	86	50	62	38	0	0	67
Hesse et al 1978 Missouri R NE	2,087				32	68	24	84	16	<1		61
Smith and Hubert 1987 Powder R WY	685			-	2	98	71	37	41	22	1	25
Gerhardt 1989 Powder R WY	1,710	0.5		0.5	2	98	65	41	35	21	3	23
Topp et al 1994 Red R MN	3,588	6.8										
Kubeny 1992 Lower James R SD	234	1.4	0.3	1.1	21	79	63	41	54	4	0	37 26

FLATHEAD CATFISH	Total Number	Total CPUE	CPUE <6 in	CPUE > =6 in	Percent < 6 in	Percent > = 6 in	RSD$_{S}$	RSD$_{11-15.9}$ (stock)	RSD16- (quality)	RSD2$_{429}$ (preferred)	RSD28-$_{59}$ (memorable)	Annual Mortality
This Study	34,316	1.8	0.3	1.5	18	82	25	83	15	1	<1	53
Stauffer et al 1996 Minnesota R MN	792	0.4	0.02	0.4	16	84	54	51	41	5	3	
Hesse et al 1978 Missouri R NE	819	-	-	-	31	69	36	73	23	3	0	54

Based on this study and my review of other studies, I recommend managers sampling channel catfish in the Missouri River set a catch rate of 5.0 cc/hnd or higher as a population objective (all lengths combined), and a catch rate of 2.0 cc/hnd as an objective for catfish 10.0 inches and larger.

Growth Rates

Growth rates of channel catfish in the Missouri River were similar to those reported in other studies on the Missouri and Mississippi rivers, other Midwest rivers, and in rivers in Wyoming and South Dakota (Table 3). However, channel catfish growth may be slower than reported by Ragland and Robinson (1972) in the 1960s. Channel catfish in our study reached 14.0 inches by age 6, 15.3 inches by age 7, 18.4 inches by age 8, and 19.6 inches by age 9 (Table 3). Slightly more than 6% of the aged channel catfish in my study were older than age 5.

Ragland and Robinson (1972) reported that channel catfish in the Missouri River in 1967 and 1968 attained 14.0 inches by age 4 and 15.0 inches by age 5 (Table 3). Catfish are capable of growing faster and reaching larger sizes than indicated by our study. Although the sample size was small, growth rates of larger channel catfish between ages 7 and 9 seem to be increasing. The apparent slowing of channel catfish growth between the late 1960s and this study may reflect the cumulative impacts of environmental changes (increasing levee heights, continuation of rock dike work to completion, and an altered hydrograph), and abundant numbers of channel catfish confined to a channelized river with less habitat diversity.

Growth rates and size attained at age are largely determined by environmental conditions and, to a lesser degree, by population size. In the Missouri River, channel catfish are capable of growing to 15.0 inches by age 5 and 23.0 inches by age 8.

Size and Age Structure

Size and age composition of the channel catfish population in the Missouri River as indicated by length frequency distribution, RSD indices, and comparisons with other channel catfish populations,

Table 3. Mean total length at time of annulus formation of channel catfish at specific ages for selected waters of the Midwest. Age (years)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Missouri R, MO This Study	2.5	6.4	9.1	11.2	13.0	14.8	16.9	19.2	20.6	21.9			
Missouri R, MO Ragland & Robinson 1972	2.1	5.5	9.4	13.0	16.2	17.8	20.0	23.2	26.6				
Missouri R, NB Hesse 1978	2.9	5.7	8.9	11.5	13.7	16.0	17.7	19.3					
Missouri R, NB Unchannelized Russell 1965	2.9	5.8	8.9	11.6	14.0	16.5	19.1	20.8	22.6	23.4			
Missouri R, NB Channelized Russell 1965	1.6	5.3	9.5	13.8	18.0	20.6	22.3						
Powder River, WY Smith & Hubert 1988			10.1	11.6	13.6	15.3	17.5	19.3	21.4	22.7	23.4	24.5	24.8
Powder River, WY Gerhardt 1989			9.5	10.4	11.5	13.3	15.3	17.3	20.2	22.8	22.4	23.4	24.3
Red River, Manitoba McDonald 1990	9.6	9.8	11.2	13.0	14.9	17.4	18.7	19.4	19.5	24.0	26.4	25.5	28.0
Red River North, MN Hegrenes 1992	5.1	6.6	7.7	12.2	12.8	14.0	15.1	16.4	18.5	20.6	22.9	24.1	25.8
Minnesota R, MN Stauffer Unpublished	4.7	7.8	10.1	12.5	14.5	16.6	18.5	20.1	21.5	22.6	23.2	24.2	25.6
Lower James R, SD Kubeny 1992	4.7	7.4	9.9	11.2	13.5	16.0	18.3	19.9	22.0	23.5	24.3	27.2	
Mississippi R, Pool 13	6.0	8.7	10.9	13.5	16.0	16.7	19.7	21.1	20.2	21.9			
Mississippi R, Pool 19	6.7	9.6	12.2	14.9	17.7	20.1	22.6	23.3	24.0	25.7			
Mississippi R, Pool 25	5.7	7.7	9.4	11.2	13.3	15.3	17.0	18.1	18.4	18.0	18.1	19.5	
Mississippi R, Chester Jahn & Raibley 1988	5.9	7.9	10.1	12.3	14.4	16.3	18.3	19.8	21.4	18.7	19.5	20.7	22.0

suggests good numbers of channel catfish up to 15.0 inches and age 6, then a marked decline with few large, old individuals in the population (Tables 1 and 3; Figure 3). Approximately 45 % of the channel catfish collected were less than 10.0 inches (range 23 % to 77 %) suggesting annual recruitment was consistent and significant. This percentage was higher than found in Wyoming and South Dakota streams (Smith and Hubert 1988, Gerhardt 1989, Gerhardt and Hubert 1991, and Kubeny 1992) (Table 2). This could help explain higher CPUE in the Missouri River compared to other streams, or it could be the inability of other investigators to sample small channel catfish. In lightly fished populations, the numbers of young fish may also be low because of predation.

Channel catfish longer than 10.0 inches comprised 55 % (range 24 % to 77 %) of my annual samples, but relatively few large fish were collected (Table 2). Approximately 21% of fish in my samples were 15.0 inches or larger (RSD_{15}) (range 9% to 33 %), but they comprised less than 15% of the samples during 5 of the last 6 years of the study. The majority of the channel catfish (86 %) were between 11.0 and 15.9 inches (stock size-RSD_{Ss-q}), but during 5 of the last 6 years, they comprised more than 92 % of the annual sample. Quality size fish, those between 16.0 and 23.9 inches (RSD_{q-p}), comprised about 14 % of the combined samples, but less than 8% during 5 of the last 6 years. Channel catfish longer than 24.0 inches comprised less than 1% of my samples. These values are similar to those reported by Hesse et al. (1978) for the Missouri River in Nebraska, but less than those for the Missouri River in Missouri during the 1960s (Ragland and Robinson 1972). Channel catfish populations in the Powder River, Red River and the Lower James River, which are lightly fished, are characterized by relatively large numbers of fish longer than 16.0 inches (Table 2).

Age structure showed that the channel catfish population in the Missouri River was comprised primarily of young fish (age 3 through age 6). Channel catfish reached 15.0 inches during their 6th growing season. Although the numbers of age 6 and older fish in the population fluctuated annually

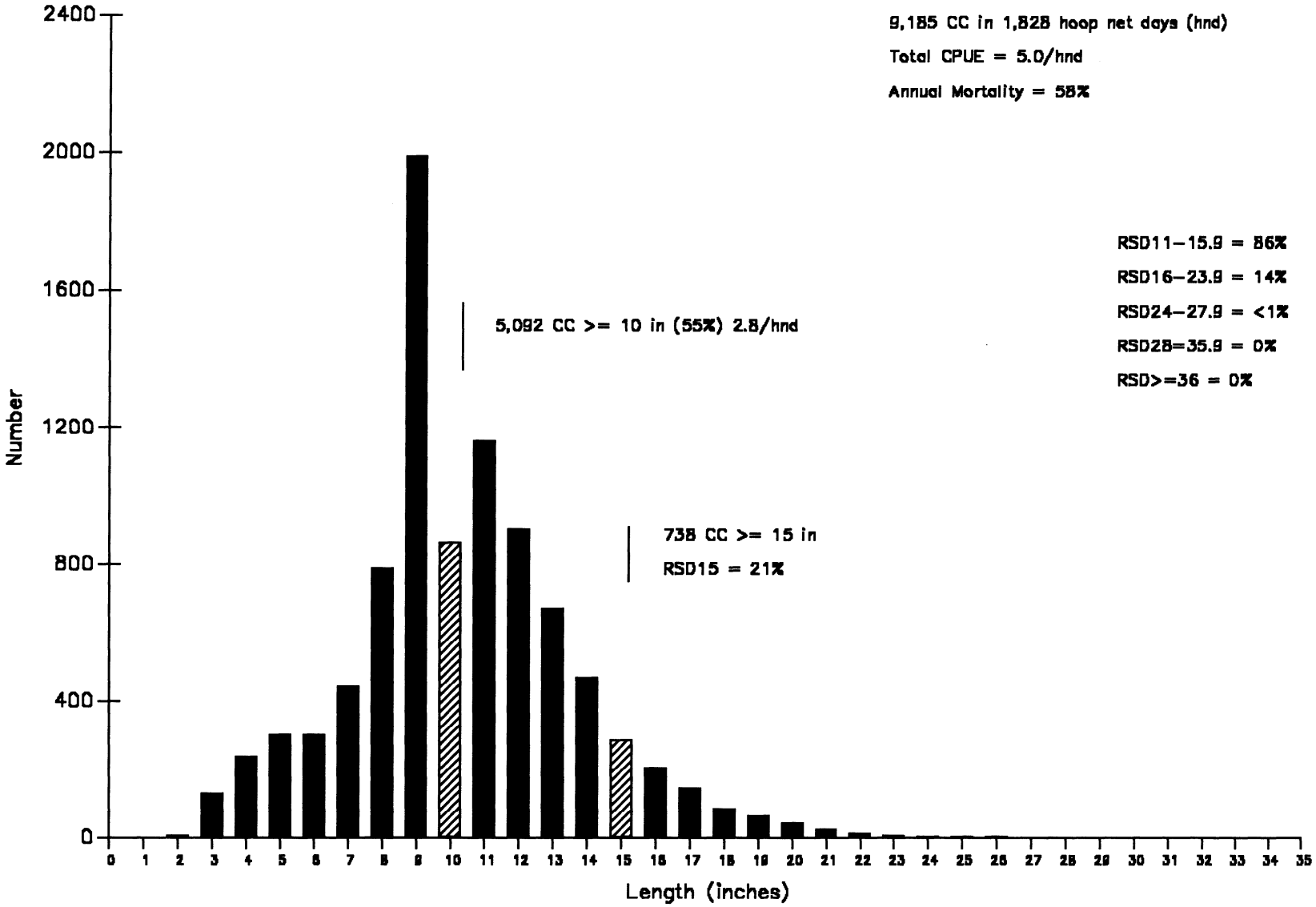

Figure 3. Length frequency, population parameters, and annual mortality rates for channel catfish from the Missouri River, 1980–1992.

during the study, the percentage of 15.0 inch and older individuals declined from a high of 33 % in 1985 and 1988, to 9% in 1989. I found few channel catfish 10 years and older in the population.

Carlander (1969) reported that channel catfish are long lived and capable of living to age 15 and older. Ragland and Robinson (1972) reported that channel catfish in the Missouri River in 1967 and 1968 grew faster and reached 16.2 inches by age 5. Smith and Hubert (1988) and Gerhardt and Hubert (1991) reported Powder River catfish reached 18 and 21 years of age, respectively, and Topp et al. (1994) found fish in the Red River of Minnesota up to 24 years of age.

Mortality Rates

Total annual mortality rates for channel catfish in the Missouri River averaged 58 % (range 45 % to 61%) and were higher than reported for the Missouri River in Nebraska (Hesse et al. 1978, Nebraska Game and Parks Commission 1982, and Hesse 1994), the Powder River in Wyoming (Smith and Hubert 1988), and the Red River in Minnesota (Topp et al., 1994) (Tables 1 and 2).

Modeling of the channel catfish population using total annual mortality rates of 30%, 40%, 50%, and 60 % (Figure 4) suggests that total annual mortality rate would have to be reduced to approximately 40%, to achieve a channel catfish population with a size and age structure similar to those found in more lightly fished and harvested streams which have higher RSD_{15}, and more quality, preferred, and even some memorable size fish. This would increase the numbers of channel catfish larger than 15.0 inches (RSD_{15}) to approximately 27%, and change the age structure to include more age 10 and older individuals in the population.

Because of higher fishing pressure in Missouri, it may not be practical to attain total annual mortality rates and a population structure similar to lightly fished and harvested populations in Wyoming, South Dakota, and Minnesota. Mortality rates could be reduced by imposing more restrictive regulations such as a high length limit or slot limits protecting specific age and length groups

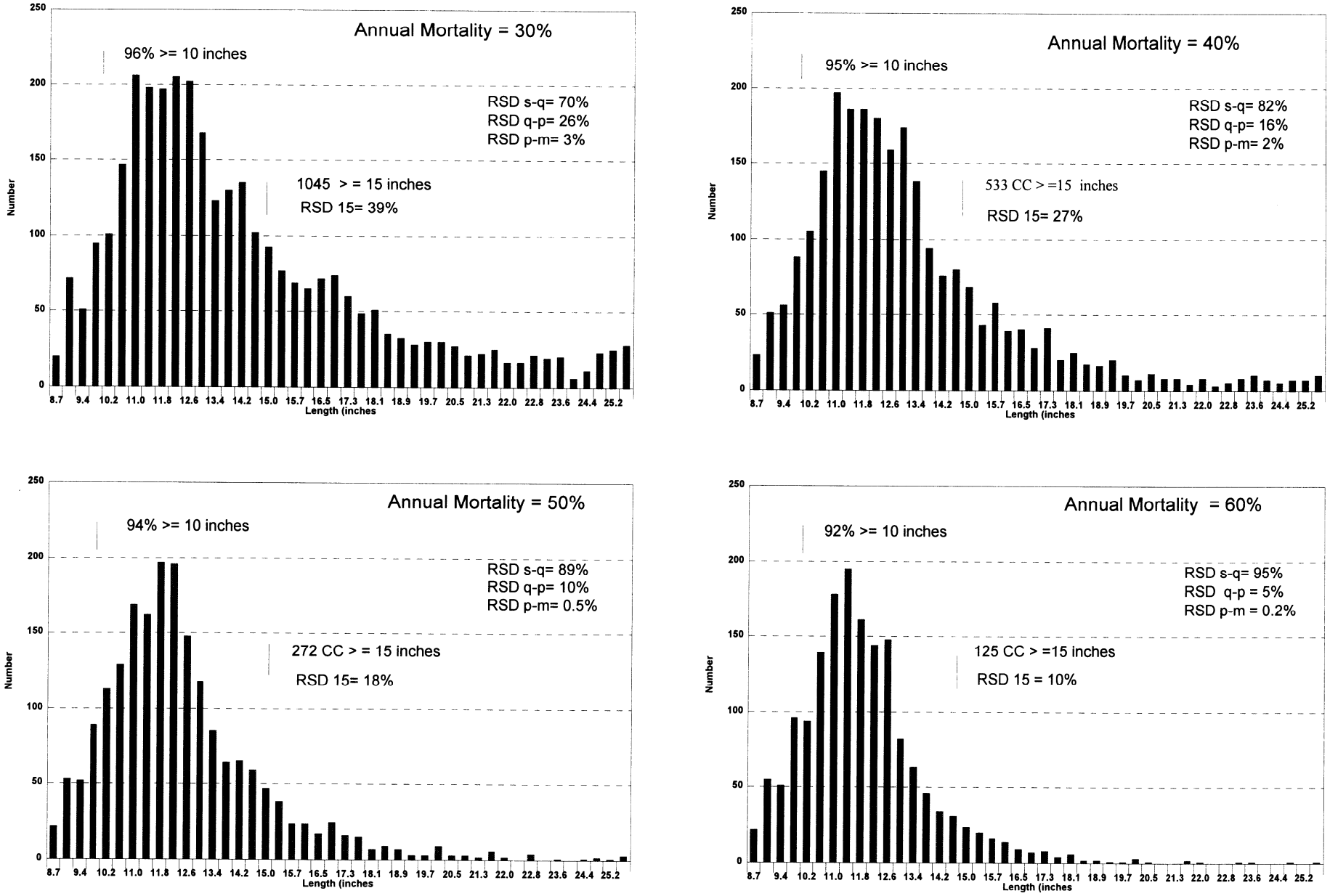

Figure 4. Population parameters of 1,000 Age 3 and older channel catfish modeled with differing annual mortality rates (A).

of individuals. Based on modeling, I recommend managers set a population objective of 25 % for channel catfish 15.0 inches and larger (RSD_{15}).

In summary, my data showed the channel catfish population was comprised primarily of fish less than 15.0 inches and ages 1- 6. Recruitment was adequate and growth acceptable. The population structure suggested significant mortality of channel catfish longer than 15.0 inches. Collecting channel catfish at several locations would provide better data to make decisions about the Missouri River channel catfish population.

FLATHEAD CATFISH

I collected 34,316 flathead catfish during 19,164 minutes of sampling (319 hours) from four sites on the Missouri River and two sites on the Mississippi River from 1980 to 1992 (Table 4; Figure 5). Flathead catfish collected ranged from 2.7 inches to 29.1 inches and averaged 8.9 inches. Eighteen percent were less than 6.0 inches total length; 82 % were 6.0 inches and longer. Information from individual sampling sites is presented for reference in Appendices A-L.

Flathead Catfish Population Parameters

Capture rates

Catch rates for all individuals during the 13 years of the study averaged 1.8 fhc/m (range 0.1 fhc/m to 4.0 fhc/m) (Table 4). Catch rates of flathead catfish less than 6.0 inches averaged 0.3 fhc/m (range 0.01 fhc/m to 0.9 fhc/m); for 6.0-inch and larger flathead catfish, catch rates averaged 1.5 fhc/m (range 0.07 fhc/m to 3.3 fhc/m). Catch rates for flathead catfish varied annually and between the six sampling sites but showed no detectable population trends during the 13 years of the study.

Comparison of flathead catfish catch rates with other studies was difficult because of differences in sampling techniques and lack of comparable flathead catfish studies. Flathead catfish catch rates during my study were higher than those reported by Stauffer (1996) from the Minnesota

Table 4. Population parameters and mortality rates for flathead catfish from four sites on the Missouri River and two sites on the Mississippi River, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught	30	1821	738	4782	3348	3195	2125	2975	4451	2544	2558	3853	1896	
Total CPUE	0.1	1.3	0.5	3.4	2.1	2.5	0.7	1.7	3.6	2.2	1.3	4.0	1.4	1.8
CPUE < 6 in	0.01	0.3	0.1	0.8	0.3	0.4	0.2	0.3	0.3	0.2	0.4	0.9	0.08	0.3
CPUE > = 6 in	0.07	0.9	0.4	2.6	1.8	2.1	0.5	1.4	3.3	2.0	0.9	3.1	1.3	1.5
% < 6in	17	26	27	24	14	16	22	20	8	8	33	23	6	18
% > = 6in	83	74	73	76	86	84	78	80	92	92	67	77	94	82
RSD$_{,5}$	38	29	26	25	20	36	24	30	23	18	21	23	19	25
RSD11-15.9 (stock)	75	80	84	84	87	72	85	77	83	89	86	84	87	83
RSD16.23$_{,9}$ (quality)	13	16	14	15	12	23	14	20	14	10	12	14	13	15
RSD24-27.9 (preferred)	0	3	1	1	1	3	1	3	2	<1	1	2	<1	1
RSD28-35.9 (memorable)	12	1	1	<1	<1	2	0	<1	1	1	1	<1	<1	1
RSD>36 (trophy)	0	<1	0	0	<1	<1	0	<1	< 1	0	<1	0	0	<1
Annual Mortality		40		55					52	55	63	52	59	53

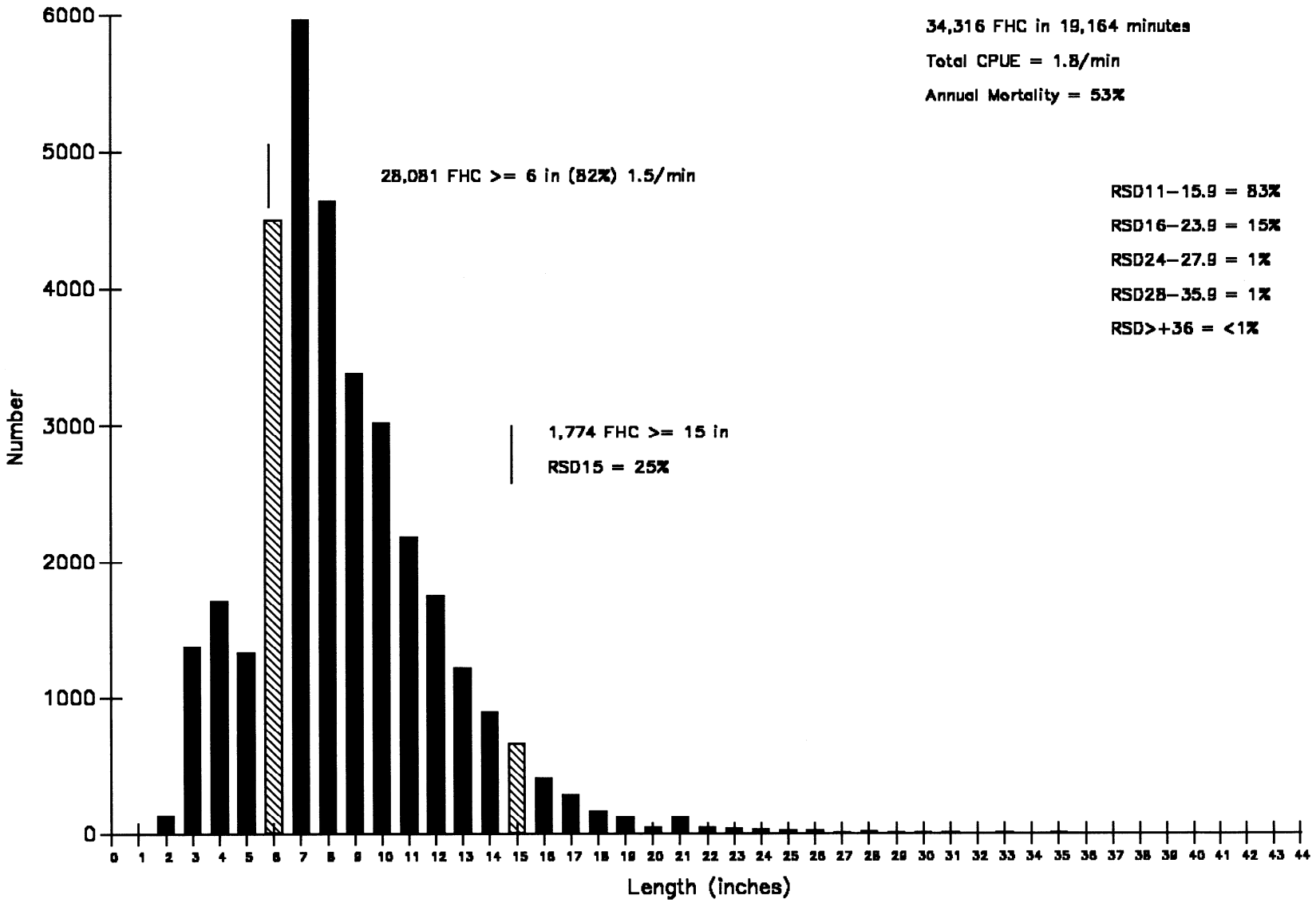

Figure 5. Length frequency, population parameters, and annual mortality rate for flathead catfish from the Missouri and Mississippi rivers, 1980–1992.

River in Minnesota, which averaged 0.4 fhc/m and ranged 0.02 fhc/m for fish less than 6.0 inches to 0.4 fhc/m for those fish 6 inches and larger (Table 2).

Although flathead catfish as small as 1.8 inches were collected by electrofishing, I do not think catch rates for small flathead catfish are representative of population abundance and I do not recommend using catch rates for flathead catfish less than 6.0 inches as population indices and particularly not as an indication of recruitment. Fish of that size are difficult to see and collect, and dippers usually select the larger fish when several fish are at the surface. This may result in considerable variability in the catch rate of small fish that may not reflect population changes. While not a direct measure of annual recruitment, length frequency distributions (6.0 inches and larger) suggest annual recruitment of flathead catfish was consistent and adequate at all sample sites.

Based on results, I recommend managers set a population objective of 1.5 fhc/m or higher for 6.0-inch and larger flathead catfish and a sample of at least 400 flathead catfish per site. Statistical correlations of total flathead catfish catch rates at the Easley site with GH ($r = -0.6$; $p = 0.05$) and GI ($r = -0.6$; $p = 0.03$) indices were significant, suggesting that as flow increased catch rates decreased. Experience has shown that electrofishing is most effective when rock dikes are exposed and the water temperature is at least 70°F.

Growth rates

Growth rates of flathead catfish from my study sites in the Missouri and Mississippi rivers were similar but slower than reported in previous studies (Table 5). Flathead catfish during my study reached 10.0 inches at age 3; 15.0 inches between ages 5 and 6; and exceeded 25.0 inches by age 10. Less than 4% of the flathead catfish in my samples were older than age 5. Earlier studies on the Missouri River in Missouri and Nebraska (Ragland and Robinson 1972, Hesse 1978, and Holz 1969) and in the Minnesota River (Stauffer et al. 1996) reported flathead catfish reached 15.0 inches between ages 3 and 4. Stauffer et al. (1976), and Ragland and Robinson (1972), reported flathead catfish living

Table 5. Mean total length at time of annulus formation of flathead catfish at specific ages for selected waters of the Midwest.

	Age (years)											
	1	2	3	4	5	6	7	8	9	10	11	12
Missouri R, MO St. Joseph, This study	4.9	7.2	10.1	12.4	14.9	16.6	21.3	21.4			23.4	24.2
Missouri R, MO Lexington, This study	4.5	7.2	9.7	11.8	14.8	16.7	21.9	20.9	24.4		29.2	31.6
Missouri R, MO Glasgow, This study	3.0	7.6	9.9	11.8	13.2	15.3	17.2	21.9	23.8	25.6		
Missouri R, MO Easley Area, This study	4.6	7.1	9.7	11.9	15.2	16.8	21.6	21.5	24.1	26.1	24.5	31.9
Missouri R, MO Crystal City, This study	5.5	7.8	10.2	12.3	13.3	16.5	17.4	20.5	24.0	26.4		
Missouri R, MO Cape Girardeau, This study	5.3	7.8	10.3	12.2	13.3	16.3	17.3	19.9	22.1	22.6	27.0	
Missouri R, MO This study, All areas	4.7	7.4	9.9	12.2	14.5	16.5	19.3	20.7	23.5	25.4	26.5	27.1
Missouri R. NE Hesse 1978	3.8	7.3	11.3	15.6	17.7	19.3	23.9	25.8				
Salt R. MO Purkett 1958	3.0	6.1	9.1	11.8	13.7	16.6	17.8	19.8	23.6			
Minnesota R, MN Stauffer et al 1996	3.8	7.7	12.6	17.2	20.5	22.9	25.6	28.7	29.6	31.4	36.7	34.4
Unchannelized MO R, NE Holz 1969	3.1	6.7	10.2	13.0	15.6	17.9	20.4	22.0	23.5	28.2		
Channelized MO R, NE Holz 1969	3.0	7.4	12.6	16.2	19.2	21.3	21.1	21.3				
Missouri R. MO Ragland and Robinson 1972	2.4	5.9	10.9	16.2	20.3	23.0	26.1	27.0	30.1	31.7	33.0	35.9

12 years and older, and growing to over 35 inches. The only flathead catfish growth rates slower than those found in my study, were reported by Purkett (1958) from the Salt River, where flathead catfish reached 15.0 inches between ages 5 and 6, then slowed reaching only 23.6 inches by age 9.

Although growth rates for flathead catfish were adequate, growth for age 4 and older fish in the population had slowed from previous studies, especially those conducted in the 1960s. Growth rates for young and small flathead catfish ages 0 through 2 were similar to other studies, then slowed after fish reached 10.0 inches and larger, increasing the time required to reach 15.0 inches or larger. In the Missouri and Mississippi rivers, flathead catfish are capable of growing to 15.0 inches by age 5 or sooner, and 21.0 inches by age 8.

Size and Age structure

Size and age composition of flathead catfish in the Missouri and Mississippi rivers, as indicated by length frequency distribution, RSD indices, and comparisons with other flathead catfish populations, suggests good numbers of individuals up to 15.0 inches and age 5, then a marked decline with few large, old individuals in the population (Tables 2 and 4; Figure 5). Recruitment, as indicated by the length frequency distribution, was adequate to maintain a healthy population in both rivers.

The flathead catfish population in the Missouri and Mississippi rivers were comprised of good numbers of fish between 6.0 inches and 15.0 inches, but few, large, quality size, individuals (Table 4). Approximately 25 % of catfish in my samples were 15.0 inches and larger (RSD_{15}) (range 18% to 38%). The flathead catfish population was comprised primarily of fish of stock size (11.0 to 15.9 inches--RSD_{Ss-q}) 83 % (range 75 % to 89 %) and quality size (16.0 to 23.9 inches--RSD_{p-m})15 % (range 10.1 to 23.1). Fish of larger sizes, preferred size (24.0 to 27.9 inches--RSD_{p-m}), memorable size (28.0 to 35.9 inches--RSD_{m-t}), and trophy size (36.0 inches and larger--RSDt) each comprised less than 1% of the population. There appeared to be adequate numbers of stock size and quality size flathead catfish, but few longer than 24.0 inches. The population appeared stable during the study.

Comparisons of population parameters with other flathead catfish populations suggests that populations in the Missouri and Mississippi rivers had more 10.0 to 15.0-inch individuals and fewer large, old individuals than Stauffer et al. (1996) reported in the Minnesota River, but was similar to the population structure reported by Hesse et al. (1989) for the Missouri River in Nebraska.

Flathead catfish populations in the Missouri and Mississippi rivers consist mainly of individuals up to 15.0 inches. Regulations reducing harvest of catfish greater than 15.0 inches would improve population characteristics and provide more quality size flathead catfish for anglers.

Mortality rates

Total annual mortality rates for flathead catfish in the Missouri and Mississippi rivers in my study were high and averaged 53 % (range 40 % to 63 %). At these rates, few flathead catfish in the Missouri and Mississippi rivers live longer the age 5 and 15.0 inches.

Modeling of the flathead catfish population using mortality rates of 30% , 40% , 50 % and 60% suggests that mortality rates would have to be reduced to 40 % or less to increase the numbers of large and old flathead catfish in the population (Figure 6). This would improve the size structure of the population and increase the numbers of large flathead catfish. The population of fish 15.0 inches and larger (RSD_{15}) would increase to approximately 37%; quality size fish (16.0 to 23.9 inches--RSD_{q-p}) would increased to 16%; preferred size fish (24.0 to 27.9 inches--RSD_{p-m}) would increase to 5%; and memorable size fish (28.0 to 35.9 inches--RSD_{m-t}) would increase to 7%.

In summary, my data showed that flathead catfish populations in the Missouri and Mississippi river was comprised primarily of fish less than 15.0 inches and ages 1-5. Recruitment was adequate and growth acceptable. The population structure suggested significant mortality of flathead catfish longer than 15.0 inches. Based on modeling I recommend managers have a flathead catfish population objective for RSD_{15} of 35 % or higher.

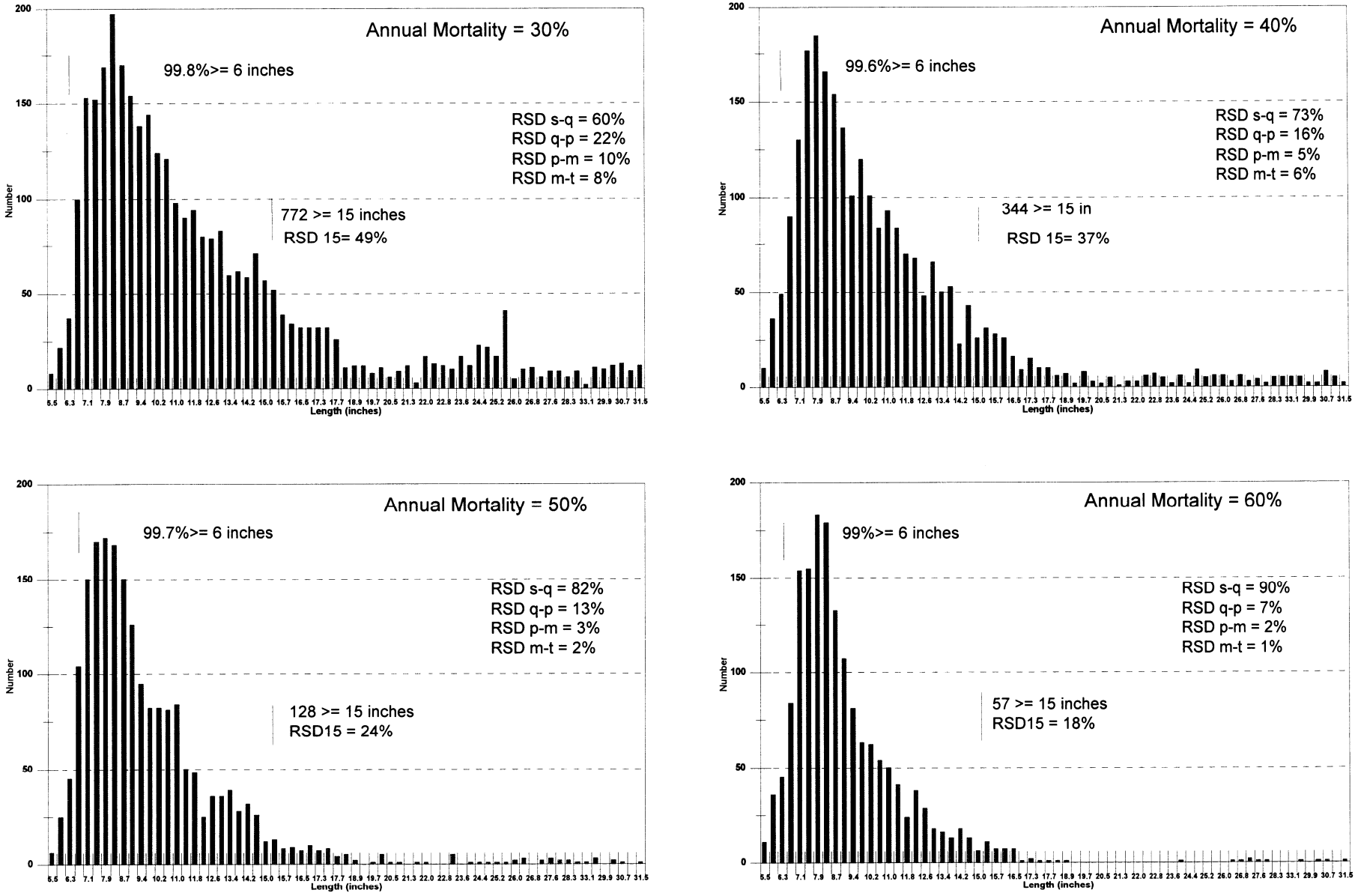

Figure 6. Population parameters of 1,000 Age 2 and older flathead catfish modeled with differing annual mortality rates (A).

MANAGEMENT IMPLICATIONS

The populations of channel catfish and flathead catfish were comprised primarily of fish less than 15.0 inches long, and ages 1-5. Recruitment was adequate and growth was acceptable. Population size and age structure suggested significant mortality of both species longer than 15.0 inches. A change in population structure for both channel catfish and flathead catfish has occurred since the 1970s when Ragland and Robinson (1972) reported RSD_{15} of 50% for the channel catfish population in the Missouri River was longer than 15.0 inches. This change also occurred while commercial harvest of catfishes (15.0 inches and longer) was increasing. From 1970 to 1990, the annual commercial harvest of catfishes from the Missouri River increased approximately six fold, from about 54,000 pounds to about 325,000 pounds (Robinson 1995). During this same time period, the commercial harvest of catfish from all rivers open to commercial fishing increased from 140,000 pounds to 598,000 pounds (Figure 1). The increased harvest occurred following a liberalization in mesh size for commercial gear from 2 inches to 1.5 inches, even though the numbers of commercial fisherman had been declining since 1982 (Figure 1). Concern about a degraded population structure and decline in population numbers of both channel catfish and flathead catfish larger than 15.0 inches resulted in regulations prohibiting the commercial harvest of catfish from the Missouri River, July 1, 1992.

Commercial reports indicated that in 1992, over 50 % of the reported catfish harvest were reported by 19 commercial fishermen. There was concern that commercial fishing was removing catfish that could and should be available to our sport fishing public. It did not make a great deal of sense that we restrict our sport fishermen to only 15 catfish (10 channel catfish and blue catfish and 5 flathead catfish) while commercial fishermen can harvest as many as they can catch provided they are larger than 15.0 inches. It was felt that a regulation to eliminate the commercial harvest of catfish was necessary. The population structures of channel catfish and flathead catfish were similar on both

rivers, but the regulation was placed only on the Missouri River because it was implemented by the States of South Dakota, Nebraska, Iowa, Kansas, and Missouri. In 1992, the entire flowing portion of the Missouri River below Gavins Point Dam was involved in this multi-state interjurisdictonal fishing regulation which was a most important step in the management of the fishery resource of the Missouri River.

Since prohibiting the commercial harvest of catfish from the Missouri River, Missouri Department of Conservation Management Section personnel have been sampling channel catfish and flathead catfish annually from eight locations on the Missouri and Mississippi rivers to determine changes in catfish populations. The information provided by my study will provide base information for this assessment.

SUMMARY and CONCLUSIONS

I sampled channel catfish populations in one study site on the Missouri River and flathead catfish at four sites on the Missouri River and two sites on the Mississippi River from 1980 to 1992 using standardized techniques (Robinson 1994), and I assessed these populations using catch rates, size and age structure, growth, and mortality rate information. Length frequency by 1.0-inch size groups, age frequency, RSD population indices, total annual mortality rates, and population modeling at 30% , 40%, 50 % and 60 % total annual mortality rates were used to describe catfish populations found in those two rivers and to compare results with other catfish populations and studies. This assessment will provide baseline information for monitoring and determining population changes, and will allow managers to assess population changes resulting from elimination of commercial harvest of catfish on the Missouri River.

The following are important findings and conclusions from my study:

Channel Catfish in the Missouri River

- Annual recruitment of channel catfish in the Missouri River was not directly measured, but based on standardized catch information and assessment of population structures it was believed to be consistent and adequate.
- Catch rates for 10.0-inch and larger channel catfish were higher than reported for other populations in the Missouri River and other northern rivers.
- High water reduced channel catfish catch rates.
- Channel catfish growth in the Missouri River has slowed since the 1960s; channel catfish in my study reached 14.8 inches by age 6, 16.9 inches age 7, 19.2 inches age 8, and 20.6 inches by age 9.
- Size and age composition of the channel catfish population in the Missouri River as suggested by RSD indices and comparisons with other populations was good for individuals up to 15.0 inches and age 6; however, the population contained few, large old individuals.
- The numbers of individuals 15.0 inches and larger (RSD_{15}), a size harvested by commercial anglers and desired by sport anglers, averaged 21 % and declined during the study. Conversely, the proportion of stock size fish (11.0 to 15.9 inches--RSD_{S_q}) in the population averaged 86 % and increased during the study. Both population indices suggest that the size composition of channel catfish in the Missouri River and the numbers of large individuals in the population had declined.
- Total annual mortality of channel catfish in the Missouri River averaged 55 % and population modeling suggested that to increase the numbers of 15.0-inch and larger fish (RSD_{15}) in the population, and the numbers of quality size individuals 16.0 inches and larger, total annual mortality would have to be reduced to 40 % or less.

Flathead Catfish in the Missouri and Mississippi Rivers

- Annual recruitment of flathead catfish in the Missouri and Mississippi rivers was not directly measured, but based on standardized catch information and assessment of population structures it was consistent annually and adequate to maintain flathead populations.
- Flathead catfish catch rates for 6.0-inch and larger fish were higher than that reported for other studies.
- Flathead catfish growth in the Missouri and Mississippi rivers was acceptable, but slower than reported for early studies on the Missouri River and in the Minnesota River. Flathead catfish grew to 10.0 inches by age 3, 14.5 inches by age 5, and exceeded 25.0 inches by age 10.
- Size and age composition of flathead catfish in the Missouri and Mississippi rivers as indicated by RSD values showed a good distribution of flathead catfish up to 15.0 inches, but few, large, quality, preferred, memorable or trophy size, individuals.
- Total annual mortality of flathead catfish in the Missouri and Mississippi river averaged 53 % and population modeling suggested that numbers of fish 15.0 inches and larger (RSD_{15}) and numbers of large flathead catfish in the two rivers, could be increased by reducing total annual mortality to 40% or less using regulations.
- Regulations restricting harvest of catfish larger than 15.0 inches would improve population characteristics and provide more quality size flathead catfish for anglers.

RECOMMENDATIONS

Channel catfish

1. Use the standardized sampling procedure following the suggestions in Robinson (1994).
2. Collect a minimum of 400 channel catfish at each sampling reach.

3. Managers sampling channel catfish should set a total catch rate of 5.0 cc/hnd or higher as a population objective (all lengths combined) and a catch rate of 2.0 cc/hnd as an objective for catfish 10.0 inches and larger. $_{RSD15}$ for channel catfish should be at least 25% .
4. Monitor the channel catfish population annually for 5 years from at least seven locations that are representative of the rivers above and below major tributaries to the Missouri and Mississippi rivers; on the Missouri River above the mouth of the Kansas River, between the Kansas River and the mouth of the Grand River, between the Grand River and the mouth of the Osage River, and between the Osage River and the mouth of the Missouri River near St. Louis; on the Mississippi River in the pooled portion above Lock and Dam 26, between Lock and Dam 26 and the mouth of the Ohio River, and below the mouth of the Ohio River, to determine if population changes occur following the 1992 regulation change and if annual mortality is reduced to 40% .
5. After this initial monitoring effort the channel catfish populations should be examined at each predetermined location every other year until the managers feel they know what is happening.

Flathead catfish

1. Use standardized sampling following suggestions in Robinson (1994).
2. Collect a minimum of 300 flathead catfish at each sample reach.
3. Managers sampling flathead catfish should use a total catch rate of 1.8 fhc/m as a population objective (all lengths combined) and a catch rate of 1.5 fhc/m for catfish that are 6.0 inches or larger. RSD_{15} should be at least 35%.
4. Monitoring of flathead catfish by Management should be continued annually for 5 years using the same general locations that are sampled for channel catfish to evaluate the regulation protecting catfish from commercial harvest and to see if it will reduce annual mortality rate to 40 % and improve the size structure.

5. After the initial monitoring effort flathead catfish populations should be examined at each predetermined location every other year until managers feel that they have a good understanding of flathead catfish population dynamics and they are satisfied with the population structure. Any new regulations may require additional sampling.

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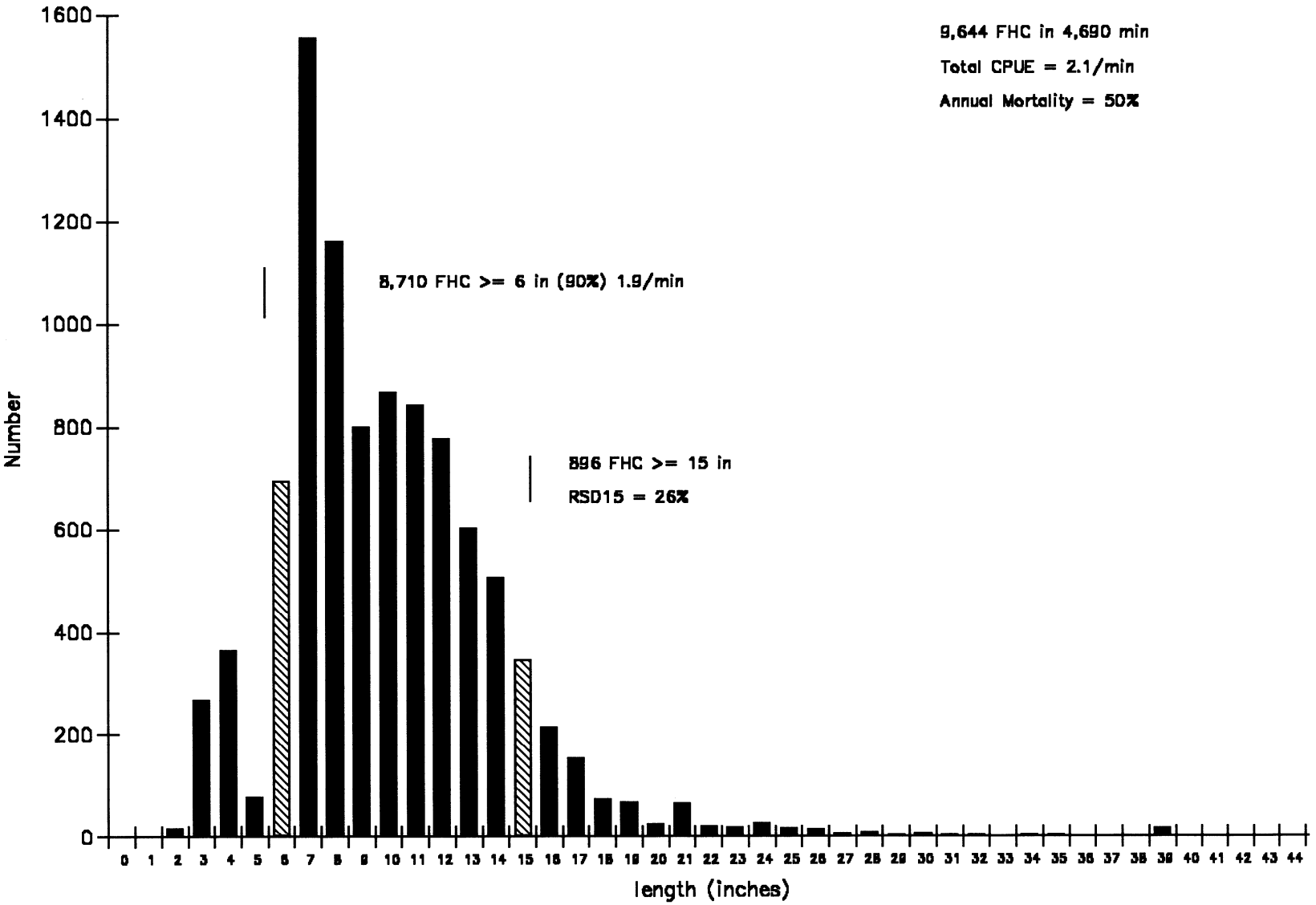
Appendix A. Population parameters, gage height, gage index, and annual mortality rates for flathead catfish caught in August and September from the Missouri River at St. Joseph, 1980-1992.

1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught			3243	1170	1229	419	560	714	651	673	558	427	
Total CPUE			3.4	2.5	2.0	0.5	1.3	3.3	3.8	2.3	1.9	1.2	2.1
CPUE < 6 in			0.4	0.2	0.2	0.06	0.06	0.3	0.2	0.4	0.2	0.05	0.2
CPUE > = 6 in			3.0	2.4	1.8	0.4	1.2	3.0	3.6	1.9	1.8	1.1	1.9
% < 6 in			13	6	8	12	5	8	6	16	9	4	10
% > = 6 in			87	94	92	88	95	92	94	84	91	96	90
RSD15			25	20	41	28	30	27	16	25	25	18	26
RSD11-15.9 (stock)			85	86	67	80	78	78	91	84	85	86	82
RSD16-23.9 (quality)			14	13	27	18	18	17	7	13	13	14	16
RSD24-27.9 (preferred)			1	<1	4	2	3	3	1	2	3	0	2
RSD28-35.9 (memorable)			<1	0	2	0	<1	2	1	1	0	<1	<1
RSD > = 36 (trophy)			0	0	0	0	1	0	<1	0	0	0	
Annual Mortality			47					47	46		44	54	50
Sample G I*			1.6	1.3	2.6	4.3	10.4	1.5	13.4	0.7	0.9	8.1	
Sample G H*			16.1	14.7	12.4	16.5	20.7	10.7	22.4	9.5	9.3	17.5	

* Data from St. Joseph Gage located at approximate Missouri River Mile 448

Appendix B. Length frequency, population parameters, and annual mortality for flathead catfish from the Missouri River at St. Joseph, 1980–1992.

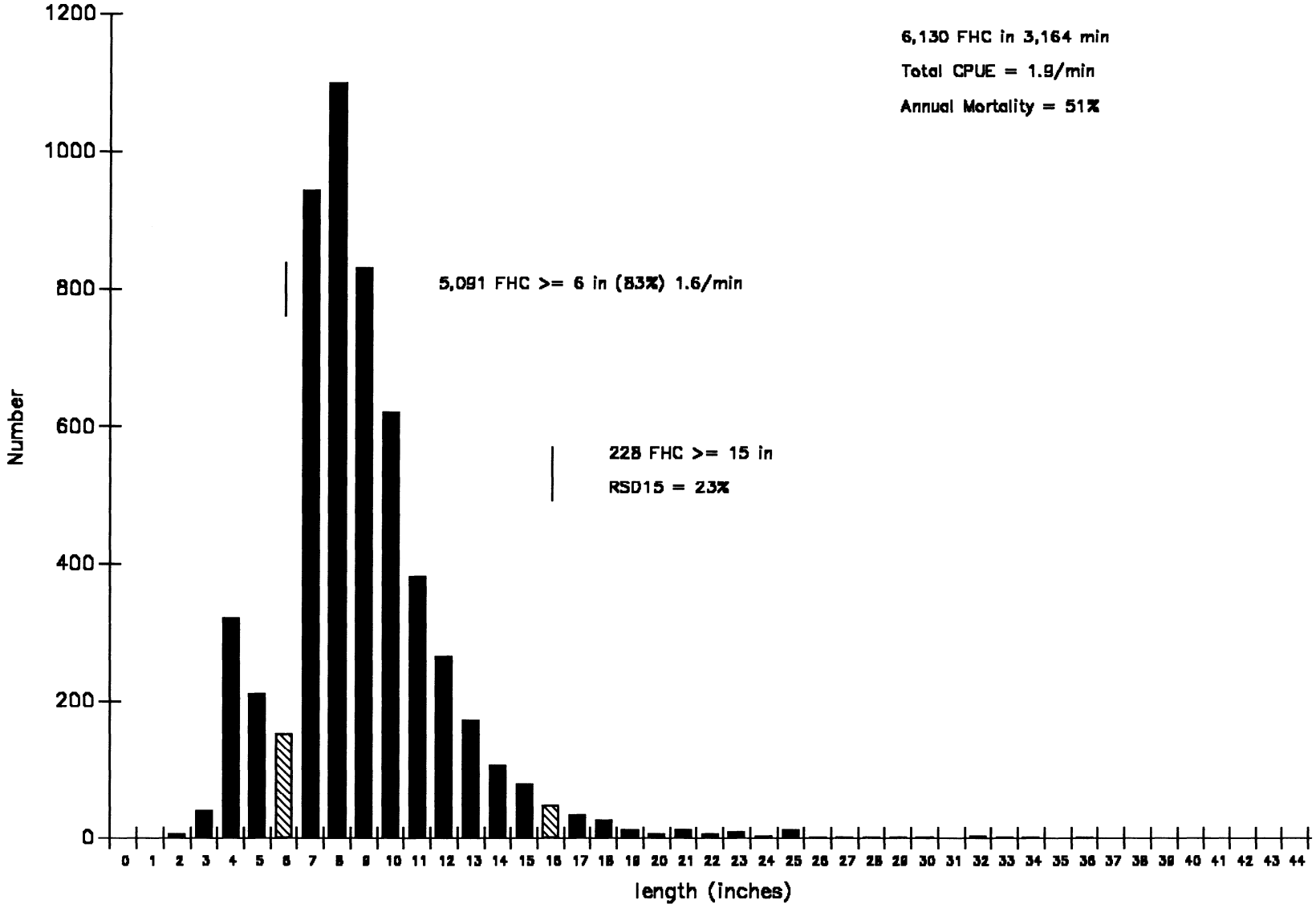


Appendix C. Population parameters, gage height, gage index, and annual mortality rates for flathead catfish caught in August and September from the Missouri River at Lexington, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught		969	344			860	477	823	868	665		692	432	
Total CPUE		1.7	0.8			2.4	0.8	2.3	5.6	3.0		4.2	1.5	1.9
CPUE < 6 in		0.5	0.2			0.4	0.06	0.5	0.4	0.3		0.9	0.02	0.3
CPUE > = 6 in		1.2	0.6			2.0	0.8	1.8	5.2	2.7		3.3	1.5	1.6
% < 6 in		31	25			18	8	21	7	11		22	2	17
% > = 6 in		69	75			82	93	79	93	89		78	98	83
RSD15		30	30			25	19	21	18	20		22	6	23
RSD11-15.9 (stock)		80	81			79	91	84	85	90		91	98	84
RSD16-23.9 (quality)		17	15			17	9	15	14	9		13	2	13
RSD24-27.9 (preferred)		2	2			2	0	1	1	0		1	0	1
RSD24-35.9 (memorable)		1	3			2	0	0	<1	1		1	0	1
RSD>=36, (trophy)		0	0			<1	0	0	0	0		0	0	<1
Annual Mortality		40							51	43		51	73	51
Sample G I*		2.2	7.2			5.9	4.8	8.2	1.3	7.2		0.9	13.2	
Sample G H*		11.3	13.8			13.6	15.0	14.0	10.1	10.6		10.0	16.0	

* Data from Waverly gage located at approximate Missouri River mile 293

Appendix D. Length frequency, population parameters, and annual mortality for flathead catfish from the Missouri River at Lexington, 1980–1992.

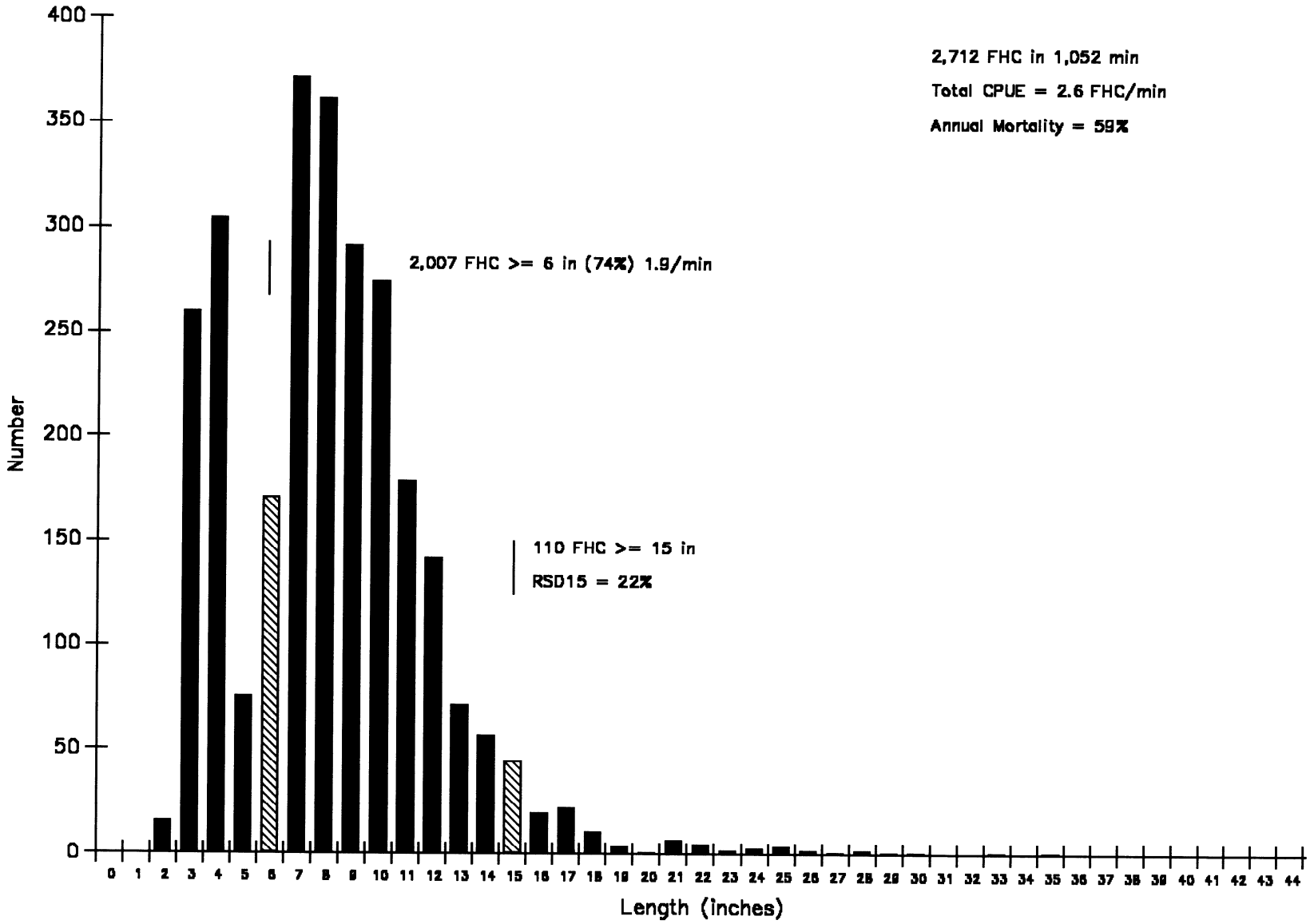


Appendix E. Population parameters, gage height, gage index, and annual mortality rates for flathead catfish caught in August and September from the Missouri River at Glasgow, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught		236	108						1001		659	608	100	
Total CPUE		2.2	0.4						3.8		4.6	8.0	0.6	2.6
CPUE < 6 in		0.4	0.06						0.4		2.4	2.5	0.03	0.7
CPUE > = 6 in		1.8	0.3						3.4		2.3	5.5	0.6	1.9
% < 6in		19	17						11		51	31	5	26
% > = 6 in		81	83						89		49	69	95	74
RSD15		31	28						16		20	26	21	22
RSD 11.15.9(stock)		79	85						91		82	81	90	85
RSD 16-23.9 (quality)		14	15						8		12	17	10	12
RSD 24-27.9 (preferred)		5	0						> 1		3	2	0	2
RSD 28-35.9 (memorable)		1	0						0		3	0	0	1
RSD>= 36(trophy)		0	0						0		0	0	0	0
Annual Mortality									52		50	52	58	59
Sample G I*		11.9	11.1						1.8		1.3	1.2	7.0	
Sample G H*		12.3	24.0						7.6		7.6	7.6	12.0	

* Data from Boonville gage located at approximate Missouri River mile 197

Appendix F. Length frequency, population parameters, and annual mortality for flathead catfish from the Missouri River at Glasgow, 1980–1992.

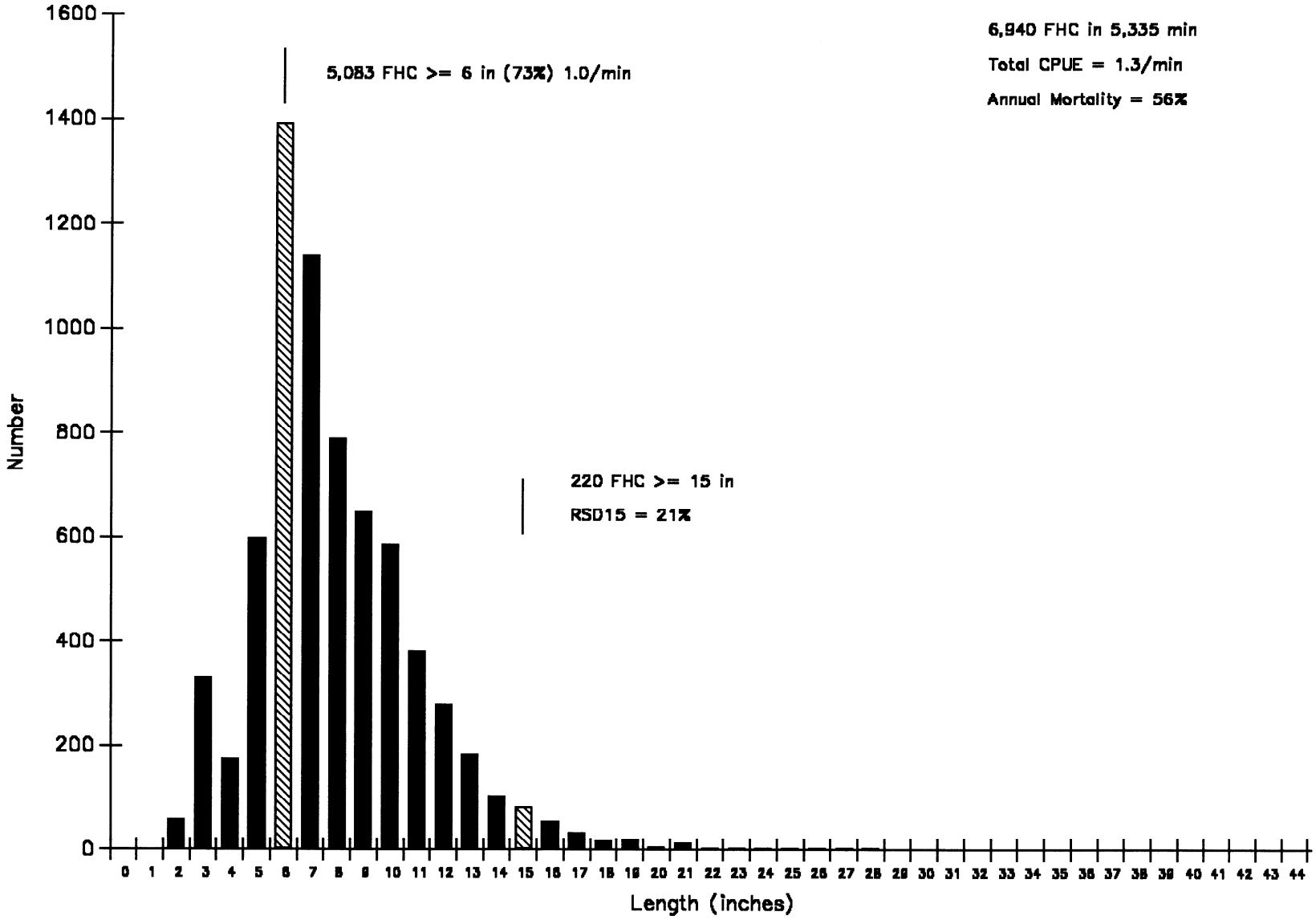


Appendix G. Population parameters, gage height, gage index, and annual mortality rates for flathead catfish from the Missouri River at Easley, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught	30	616	286	1539	1103		634	307	664	406	541	691	123	
Total CPUE	0.1	0.8	0.4	3.3	1.7		0.9	1.2	3.9	1.6	1.3	3.6	0.4	1.3
CPUE < 6 in	0.01	0.2	0.1	1.5	0.2		0.3	0.4	0.2	0.2	0.6	0.6	0.02	0.4
CPUE > = 6 in	0.07	0.6	0.2	1.8	1.5		0.6	0.8	3.6	1.5	0.7	3.0	0.4	1.0
% < 6 in	17	22	34	47	13		34	36	6	9	43	17	4	27
% >= 6 in	83	78	66	53	87		66	64	94	91	57	83	96	73
RSD_{15}	38	27	19	26	21		24	28	20	12	8	25	11	21
$RSD_{11\text{-}15.9}$ (stock)	75	80	90	81	86		88	75	90	94	95	85	95	86
$RSD16\text{-}23_{.9}$ (quality)	13	17	10	18	11		11	25	9	6	5	14	5	12
$RSD2_{4\text{-}27.9}$ (preferred)	0	1	0	1	2		1	0	1	0	0	1	0	1
$RSD_{28\text{-}35.9}$ (memorable)	12	1	0	0	> 1		0	0	0	0	0	0	0	> 1
$RSD>_{=36}$ (trophy)	0	1	0	0	> 1		0	0	0	0	0	0	0	>1
Annual Mortality				51					52	59	63	59	67	56
Sample G I*	5.6	11.9	11.1	1.7	2.3	4.5	8.9	10.1	1.8	15.5	6.5	1.0	7.0	
Sample G H*	9.3	12.2	18.8	11.0	12.4	10.2	13.9	12.7	7.6	7.1	11.4	7.4	12.0	

* Data from Boonville gage located at approximate Missouri River mile 197

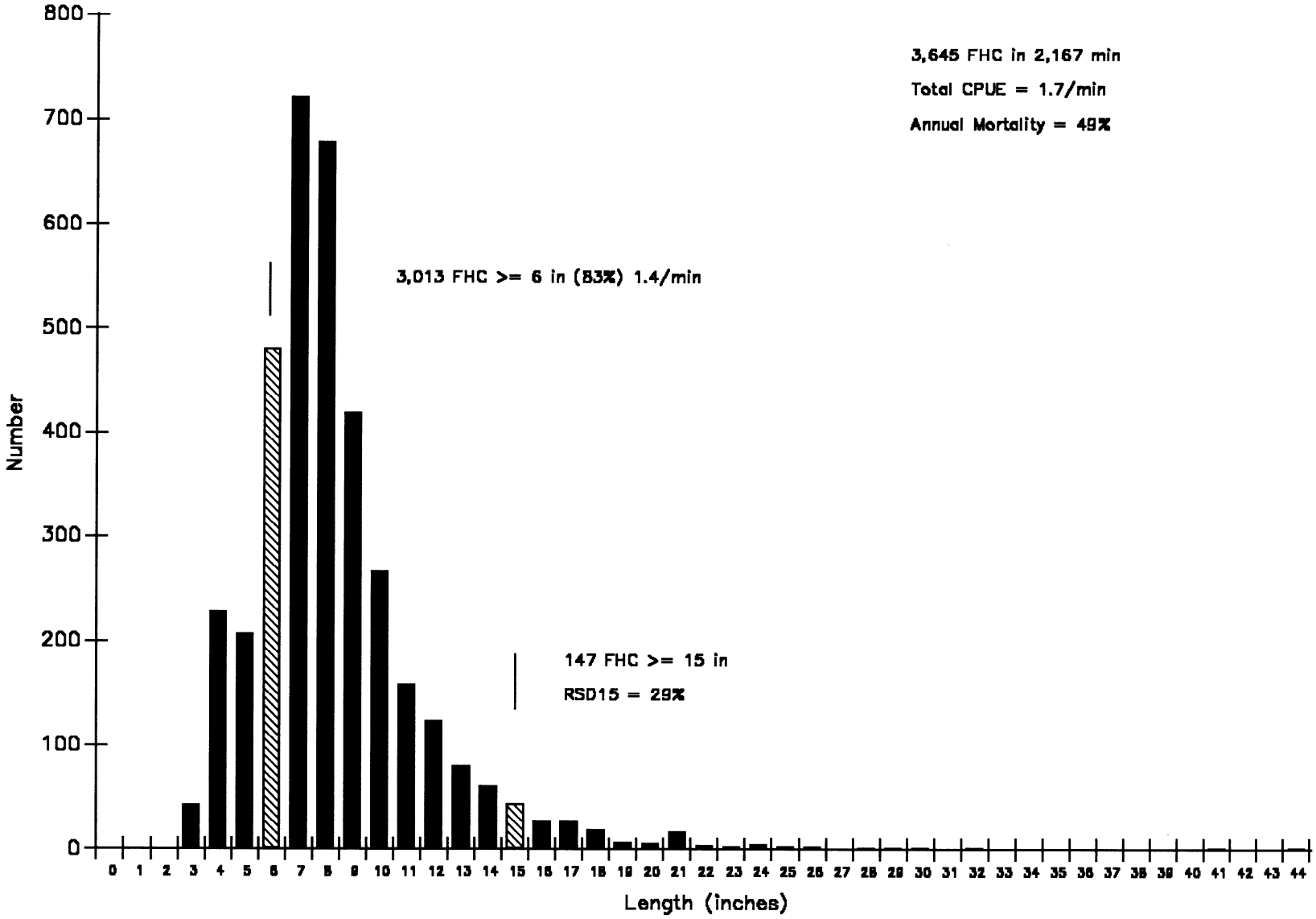
Appendix H. Length frequency, population parameters, and annual mortality for flathead catfish from the Missouri River at Easley, 1980–1992.



Appendix I. Population parameters and annual mortality rates for flathead catfish caught in August and September from the Mississippi River at Crystal City, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught							242	906	585	439	367	646	460	
Total CPUE							0.5	3.2	2.7	1.7	0.6	7.6	3.7	1.7
CPUE < 6 in							0.09	0.6	0.3	0.05	0.2	2.2	0.3	0.3
CPUE > = 6 in							0.4	2.6	2.4	1.6	0.4	5.4	3.4	1.4
% < 6 in							19	19	9	3	33	20	9	17
% >= 6 in							81	81	91	97	67	71	91	83
RSD_{15}							29	37	36	23	20	21	26	29
RS11-$1_{5.9}$ (stock)							83	70	71	80	83	86	80	78
$^{RSD}{}_{16\text{-}23.9}$ (quality)							17	26	24	17	16	13	17	20
$^{RSD}{}_{24\text{-}27.9}$ (preferred)							0	4	0	2	0	0	2	1
$^{RSD}{}_{28.35.9}$ (memorable)							0	0	3	2	1	1	0	1
RSD>= $_{36}$ (trophy)							0	0	3	0	0	0	0	< 1
Annual Mortality									43	50		51	54	49

Appendix J. Length frequency, population parameters, and annual mortality for flathead catfish from the Mississippi River at Crystal City, 1980–1992.



Appendix K. Population parameters and annual mortality rates for flathead catfish caught in August and September from the Mississippi River at Cape Girardeau, 1980-1992.

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Mean
Total No. Caught					1075	1106	353	379	619	383	318	658	354	
Total CPUE					2.3	3.5	0.8	1.0	3.1	1.5	0.8	4.5	2.2	1.9
CPUE < 6 in					0.6	0.8	0.3	0.3	0.2	0.1	0.1	0.2	0.2	0.4
CPUE > = 6 in					1.8	2.7	0.6	0.7	2.9	1.4	0.6	3.4	2.0	1.5
% < 6 in					24	23	33	27	7	9	17	26	9	20
% > = 6 in					76	77	67	73	93	91	83	74	91	80
RSD_{15}					18	32	21	27	37	38	15	18	39	25
$RSD_{11\text{-}15.9.}$ (stock)					88	80	85	82	76	73	93	85	76	83
$RSD_{I6\text{-}23.9}$ (quality)					12	18	15	16	22	27	7	13	24	16
$RSD_{24\text{-}27.9}$ (preferred)					0	2	0	2	2	0	0	2	0	1
$RSD_{28\text{-}35.9}$ (memorable)					0	0	0	0	0	0	0	0	0	0
RSD> =36 (trophy)					0	0	0	0	0	0	0	0	0	
Annual Mortality									49	46	52	43	48	51

Appendix L. Length frequency, population parameters, and annual mortality for flathead catfish from the Mississippi River at Cape Girardeau, 1980–1992.